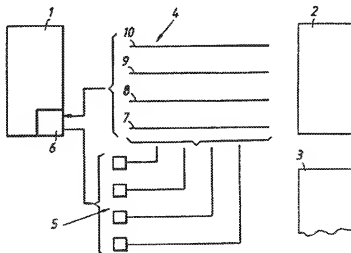




INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification ⁶: H04B 7/12, 7/26	A1	(11) International Publication Number: WO 95/10144 (43) International Publication Date: 13 April 1995 (13.04.95)
(21) International Application Number: PCT/SE94/00841 (22) International Filing Date: 12 September 1994 (12.09.94) (30) Priority Data: 9303213-4 1 October 1993 (01.10.93) SE (71) Applicant (for all designated States except US): TELIA AB [SE/SE]; S-123 86 Farsta (SE). (72) Inventors; and (75) Inventors/Applicants (for US only): ENGSTRÖM, Bo [SE/SE]; Blidvägen 189, S-976 32 Luleå (SE). LARSSON, Roger [SE/SE]; Docentvägen 53, S-951 64 Luleå (SE). (74) Agent: KARLSSON, Berne; Telia Research AB, Concern-patent, Rudsjötterrassen 2, S-136 80 Haninge (SE).		(81) Designated States: US, European patent (AT, BE, CH, DE, DK, ES, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE). Published <i>With international search report.</i> <i>With amended claims.</i>

(54) Title: ARRANGEMENT IN A MULTI-USER SYSTEM**(57) Abstract**

A multi-user system includes radio channels which are independent and uncorrelated for different users. The system operates with frequencies which, due to multi-path propagation, are more or less attenuated for one user and more or less amplified for another user. Elements (6, 6', 6'') are arranged to detect or measure the attenuation/amplification for the different frequencies. The elements also prevent signal or information transmission at frequencies which drop below a predetermined lowest attenuation by disconnecting the frequency or frequencies in question and connecting a corresponding number of frequencies which pass the attenuation value criterion.

FOR THE PURPOSES OF INFORMATION ONLY

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AT	Austria	GB	United Kingdom	MR	Mauritania
AU	Australia	GE	Georgia	MW	Malawi
BB	Barbados	GN	Guinea	NE	Niger
BE	Belgium	GR	Greece	NL	Netherlands
BF	Burkina Faso	HU	Hungary	NO	Norway
BG	Bulgaria	IE	Ireland	NZ	New Zealand
BJ	Benin	IT	Italy	PL	Poland
BR	Brazil	JP	Japan	PT	Portugal
BY	Belarus	KE	Kenya	RO	Romania
CA	Canada	KG	Kyrgyzstan	RU	Russian Federation
CF	Central African Republic	KP	Democratic People's Republic of Korea	SD	Sudan
CG	Congo	KR	Republic of Korea	SE	Sweden
CH	Switzerland	KZ	Kazakhstan	SI	Slovenia
CI	Côte d'Ivoire	LI	Liechtenstein	SK	Slovakia
CM	Cameroon	LK	Sri Lanka	SN	Senegal
CN	China	LU	Luxembourg	TD	Chad
CS	Czechoslovakia	LV	Latvia	TG	Togo
CZ	Czech Republic	MC	Monaco	TJ	Tajikistan
DE	Germany	MD	Republic of Moldova	TT	Trinidad and Tobago
DK	Denmark	MG	Madagascar	UA	Ukraine
ES	Spain	ML	Mali	US	United States of America
FI	Finland	MN	Mongolia	UZ	Uzbekistan
FR	France			VN	Viet Nam
GA	Gabon				

ARRANGEMENT IN A MULTI-USER SYSTEMTECHNICAL FIELD

The present invention relates to an arrangement in a multi-user system comprising radio channels which are independent and uncorrelated for different users and in which frequencies, due to multi-path propagation, are more or less attenuated for one user and more or less amplified for another user.

PRIOR ART

There are time-dispersive radio channels in which signalling occurs in an environment which causes reflections with significant amplitude and long delays. In digital radio systems, a radio channel is usually designated as frequency-selective when the reflections have delays which are longer than the symbol length. By this is meant that different frequencies in the spectrum, of the signal are dispersed in different ways. In particular, it can be noticed that the different frequencies are attenuated by different amounts. The traditional methods for signalling in such an environment are, among others, different arrangements for achieving diversity, use of equalizers, use of a so-called RAKE receiver or suitable channel coding.

OFDM (Orthogonal Frequency Division Multiplex) is a form of modelling in which a broadband signal is multiplexed on many narrow-band channels, normally several hundred. The narrow-band channels can be packed very tightly since the fact is utilized, that the channels are orthogonal when the channel separation (Hz) is equal to $1/\text{symbol length}$ for rectangular symbols. OFDM is normally implemented with the aid of special circuits which carry out FFT (Fast Fourier Transform) very rapidly.

In OFDM signalling, channel coding is normally used for reducing error probability. OFDM combined with channel coding is called COFDM (Coded Orthogonal Frequency Division Multiplex). Systems which use this

- 2 -

form of signalling have in recent years been implemented for different types of broadcasting, that is to say one-way systems for digital radio broadcasting and for high-resolution digital TV. More recently, interest has also
5 begun to be shown for utilizing the good characteristics of OFDM for two-way communication, for example in mobile systems, radio LANs and for point-to-multipoint applications.

In traditional OFDM systems, attempts are usually
10 made to cope with the frequency-selective fading by coding out the errors which arise in the frequencies which are highly attenuated.

DESCRIPTION OF THE INVENTION

TECHNICAL PROBLEM

15 Quite generally there is a need to be able to eliminate the fading problem in a simpler manner than, for example, by coding methods. The invention intends to solve this problem, among others. In a system of this type, there is the requirement that it should be possible
20 to hold the frequency attenuation above certain predetermined values for all users in the system. The invention also intends to solve this problem.

SOLUTION

25 That which can be mainly considered to be characterizing of an arrangement according to the invention is that elements are arranged to sense or measure the attenuation/amplification at the different frequencies and to prevent signal links or information transmission at frequencies which drop below a predetermined lowest
30 permitted or stipulated attenuation.

In one embodiment of the concept of the invention, the multi-user system comprises both uplinks and downlinks. In the uplinks or outstations of a base station, the said elements/basestation measure(s) the
35 attenuation at the different frequencies or, respectively, the different outstations. On the basis of the

- 3 -

measurement made, the elements/basestation distribute(s) the frequencies at which the different outstations are to signal or send information. The multi-user system in the said embodiment can also include downlinks, that is to say basestation to outstations. Each of the latter outstations or said elements measures the attenuation for each frequency. The result of the measurement is signalled to the basestation/said elements which distribute(s) the frequency.

In a preferred embodiment, an OFDM system is utilized in which an identifiable data symbol for each carrier wave used can be easily extracted. When a respective identifiable data symbol appears, the possibility exists of obtaining attenuation by comparison of transmitted and received amplitudes. The said elements detect the said frequencies continuously or detect variation of a respective radio channel in the system at predetermined time intervals. In this manner, adaptive signal or information transmission coupled in and out is obtained as the frequency attenuation exceeds or respectively drops below the predetermined attenuation.

The arrangement also operates when a multiplexing function is in use which allows overlapping between the users. The said OFDM system is utilized for a number (small number) of users, for example four users, and operating with a substantially greater number of carrier waves, for example 128 carrier waves, whereby the element is arranged to carry out measurements and determinations of the attenuation value on all or, with optimization, a predetermined number of carrier waves.

According to the invention, there are also distinctive features regarding the operation of the element. The said element is to be arranged to search for the lowest amplitude among all carrier waves affected which at that time is not allocated to any user. The element is also to seek out all users in this connection. The element is furthermore arranged to allocate the carrier wave thus found/taken out to a user to whom a sufficient number of carrier waves has not been allocated

- 4 -

on the occasion in question and also has most to gain by using the carrier wave found, whereby the selection criterion can be the highest amplitude in relation to the mean amplitude of the user. The element can repeat these functions until all users have been allocated as many carrier waves as are needed for the signal or information transmission in question. The element is also to repeat the said functions as often as is needed in order to follow the variations of the radio channel.

10 ADVANTAGES

Through that which has been proposed above, an effective signal and information transmission is achieved in the system. All users can obtain good quality in their radio channels. It can be mentioned in this connection that the mean power can be increased considerably for all users and an example of an increase of between 3-5 dB for all users can be achieved in spite of the fact that the attenuation can go down to minus 37 dB relative to the maximum power for certain frequencies. As an example it can be mentioned that carrier waves which are attenuated by more than minus 13 dB have not been used in the case specified here.

DESCRIPTION OF THE FIGURES

A presently proposed embodiment of an arrangement which exhibits the characteristics which are significant of the invention will be described in the text below, at the same time referring to the attached drawings, in which

Figure 1 shows an OFDM system with uplinks from outstations to the basestation and where frequencies are measured and distributed amongst users,

Figure 2 shows, in a basic form, downlinks from a basestation to an outstation where the frequencies are measured in a respective outstation and the result is signalled back to the base station which carries out the frequency distribution to

- 5 -

the users, and
Figure 3 shows, in a diagram form, frequency allocation
for four users on 128 carrier waves where all
users signal at 32 frequencies and where no
5 overlap is allowed.

DETAILED EMBODIMENT

In Figure 1, a basestation is designated by 1 and
outstations are represented by 2 and 3. There can be
several outstations. The uplinks are basically designated
10 by 4 and users by 5. The basestation is in this case
provided with an element 6 which, in a manner known per
se, is arranged to measure the attenuation at respective
frequencies which have been symbolized by 7, 8, 9 and 10.
Depending on the measurement, different frequencies are
15 adaptively coupled in and out. In the case where the
frequencies are attenuated and assume a lowest permitted
attenuation, there is no information or signal trans-
mission via the said frequency. Instead, another
frequency is selected in accordance with the present
20 invention. The users 5 are thus assured at any instant of
an adequate number of frequencies with attenuations above
the said permitted attenuation. The element senses the
frequencies continuously or at certain intervals which
are set in accordance with the radio channels in question
25 and ensures good transmission. The coupling together of
selected frequencies and users has been symbolized by a
matrix form.

The said OFDM system can also include downlinks
7 between the basestation 1' and the outstations 2' or,
30 respectively, 3' and so forth. The said elements are then
arranged both at the base station and a respective
outstation and have been given the designations 6' and,
respectively, 6". The attenuation is measured by means of
the element part at a respective outstation. The result
35 of the measurement is transferred to the basestation, for
example via a signal channel 8. The element part 6'
thereafter carries out the distribution of approved
frequencies to the different users 5' in a corresponding

- 6 -

manner to that above.

The OFDM system has advantages in connection with the said measuring function in that it naturally operates with a data symbol for each carrier wave used. The data symbol can be easily identified for the respective carrier wave and the attenuation can be obtained by comparing the received amplitude with the transmitted amplitude.

Figure 3 is intended to illustrate an embodiment example in which frequency allocation has been carried out in a large OFDM system for four users and altogether 128 carrier waves. All users signal at 32 frequencies. In the present case, a multiplexing method which allows overlapping between the users has not been utilized even though such an application is possible per se. The system operates with an algorithm for frequency allocation which is simple and which has not been optimized for minimizing the quantity of data which has to be signalled to the base station in a downlink. Neither has the measuring method been optimized but, instead, it is assumed that all frequencies are measured for all users. The algorithm guarantees that the most attenuated carrier waves are not used for signalling except in the rare cases where all radio channels are weak at the same frequency.

The said elements 6, 6' and 6" operate with the following algorithm:

1. Seek out the lowest amplitude among all unallocated carrier waves and all users.
2. Allocate the carrier wave found to the user who has not been allocated a sufficient number of carrier waves and who, moreover, has most to gain from using the carrier wave found, whereby the selection criterion can be the highest amplitude in relation to the mean amplitude of the user.
3. Repeat the above according to items 1 and 2 until users have obtained as many carrier waves as are needed.
4. Repeat the above according to items 1-3 as often as is needed for following the variation of the radio

- 7 -

channel.

Figure 3 shows the result for four users. In the upper part of the figure, the amplitudes of the four different radio channels are shown for different frequencies. The numbers in the top figure and dashes in the lower figure show which frequencies have been allocated to each user. The diagram according to Figure 3 shows that the frequencies which have been allocated largely have the same amplitudes which lie at a maximum for all the four radio channels. This situation naturally reflects optimum conditions. It is not always possible to achieve a maximum since each user is to be allocated a certain number of carrier waves. In the example, the mean power has increased between 3 and 5 decibels for all users. Even though there are attenuations at down to minus 37 dB relative to the maximum power, no carrier wave is used which is more attenuated than minus 13 dB.

The invention is not limited to the embodiment shown in the above as an example but can be subjected to modifications within the scope of the subsequent patent claims and the concept of the invention.

PATENT CLAIMS

1. User arrangement in a multi-user system comprising radio channels which are independent and uncorrelated for different users (5, 5') and in which frequencies 7, 8, 9, 10, due to multi-path propagation, are more or less attenuated for one user and more or less amplified for another user, and so forth, characterized in that elements (6, 6', 6'') are arranged to detect or measure the attenuation/amplification at the different frequencies and to prevent signal or information transmission at frequencies which drop below a predetermined lowest permitted attenuation.
2. Arrangement according to Claim 1, characterized in that the multi-user system includes both uplinks and downlinks 4 and, respectively, 7, in that in the uplinks, that is to say from the outstations to a basestation (1), the said element 6/the basestation measures the attenuation for the different frequencies and distributes, depending on the measurements, the frequencies at which the different outstations are to signal or transmit information.
3. Arrangement according to Claim 1 or 2, characterized in that the multi-user system includes downlinks 7, that is to say from a basestation to outstations 2', 3', in that each of the last-mentioned outstations measures the attenuation at every frequency and in that the result of the measurement is signalled to the basestation 1'/said element 6' which distributes the frequencies amongst the users.
4. Arrangement according to any of the preceding claims, characterized in that the system in question is an OFDM system in which an identifiable data symbol for each carrier wave used can be extracted, in that on the appearance of a respective identifiable data symbol, the possibility exists for obtaining the attenuation by comparison of transmitted and received amplitudes.
5. Arrangement according to any of the preceding claims, characterized in that the element detects said

- 9 -

frequencies continuously, or at predetermined time intervals detects a respective radio channel variation in the system and in this manner adaptively couples frequencies in and out for signalling or respectively transmission of information as the frequency attenuation exceeds or, respectively, drops below predetermined attenuation values.

5
6. Arrangement according to any of the preceding claims, characterized in that it is activated even in the case where a multiplexing function is in use which allows overlapping between the users.

10
7. Arrangement according to any of the preceding claims, characterized in that it includes an OFDM system for a number of users, for example four users, and operates with a considerably greater number of carrier waves, for example 128 carrier waves, whereby the element is arranged to carry out measurements and determinations of attenuation values on all or, with optimization, a predetermined number of carrier waves.

15
20 8. Arrangement according to any of the preceding claims, characterized

a) in that the element is arranged to seek out the lowest amplitude among all affected carrier waves which at that time is not allocated to any user, and to seek
25 out all users,

b) in that the element is arranged to allocate the carrier wave thus found/taken out to a user to whom a sufficient number of carrier waves has not been allocated and, moreover, has most to gain from using the carrier
30 wave found, whereby the selection criterion can be the highest amplitude in relation to the mean amplitude of the user,

c) in that the element repeats the functions according to a and b until all users have received as many carrier waves as are needed, and
35

d) in that the element (6, 6', 6") repeats the functions according to a, b and c as often as is needed for following the variations of the radio channels.

9. Arrangement according to any of the preceding

- 10 -

claims, characterized in that allocated frequencies are given amplitudes which are essentially at a maximum for all the four radio channels.

10. Arrangement according to any of the preceding claims, characterized in that the users are allocated a predetermined number of frequencies which is the same for all users, in that the element (6, 6', 6'') detects/measures all the frequencies of the system continuously or at intervals which can be predetermined, and in that the element connects and disconnects frequencies to the users in dependence on the variation in the frequency attenuations.

AMENDED CLAIMS

[received by the International Bureau on 20 March 1995(20.03.95); original claims 1 and 4 amended; remaining claims unchanged (3 pages)]

1. User arrangement in a multi-user system comprising radio channels which are independent and uncorrelated for
5 different users (5, 5') and in which frequencies 7, 8, 9, 10, due to multi-path propagation, are more or less attenuated for one user and more or less amplified for another user, and so forth, **characterized** in that the system is an orthogonal frequency division multiplex (OFDM) system having a data
10 symbol for each carrier wave used and in that elements (6, 6', 6'') are arranged to detect or measure the attenuation/amplification at the different carrier wave frequencies and to prevent signal or information transmission at frequencies which drop below a predetermined lowest permitted attenu-
15 ation.
2. Arrangement according to claim 1, **characterized** in that the multi-user system includes both uplinks and downlinks 4 and 7 respectively, in that in the uplinks, that is to say from the outstations to a basestation (1), the said
20 element 6/the basestation measures the attenuation for the different frequencies and distributes, depending on the measurements, the frequencies at which the different outstations are to signal or transmit information.
3. Arrangement according to claim 1 or 2, **character-**
25 **ized** in that the multi-user system includes downlinks 7, that is to say from a basestation to outstations 2', 3', in that each of the last-mentioned outstations measures the attenuation at every frequency and in that the result of the measurement is signalled to the basestation 1'/said element
30 6' which distributes the frequencies amongst the users.
4. Arrangement according to any of the preceding claims, **characterized** in that an identifiable data symbol for each carrier wave used can be extracted, in that on the appearance of a respective identifiable data symbol, the possibility
35 exists for obtaining the attenuation by comparison of transmitted and received amplitudes.
5. Arrangement according to any of the preceding claims, **characterized** in that the element detects said frequencies continuously, or at predetermined time intervals detects a
40 respective radio channel variation in the system and in this

manner adaptively couples frequencies in and out for signalling or respectively transmission of information as the frequency attenuation exceeds or, respectively, drops below predetermined attenuation values.

5 6. Arrangement according to any of the preceding claims, **characterized** in that it is activated even in the case where a multiplexing function is in use which allows overlapping between the users.

7. Arrangement according to any of the preceding claims, **characterized** in that it includes an OFDM system for a
10 number of users, for example four users, and operates with a considerably greater number of carrier waves, for example 128 carrier waves, whereby the element is arranged to carry out measurements and determinations of attenuation values on all
15 or, with optimization, a predetermined number of carrier waves.

8. Arrangement according to any of the preceding claims, **characterized**

a) in that the element is arranged to seek out the
20 lowest amplitude among all affected carrier waves which at that time is not allocated to any user, and to seek out all users,

b) in that the element is arranged to allocate the carrier wave thus found/taken out to a user to whom a
25 sufficient number of carrier waves has not been allocated and, moreover, has most to gain from using the carrier wave found, whereby the selection criterion can be the highest amplitude in relation to the mean amplitude of the user,

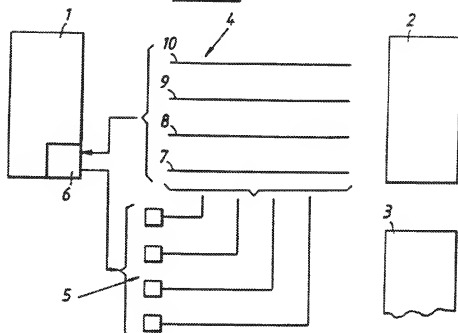
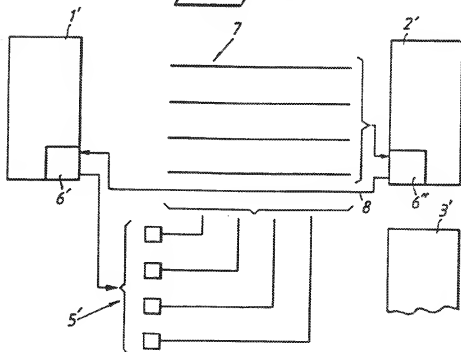
c) in that the element repeats the functions according
30 to a and b until all users have received as many carrier waves as are needed, and

d) in that the element (6, 6', 6'') repeats the functions according to a, b and c as often as is needed for following the variations of the radio channels.

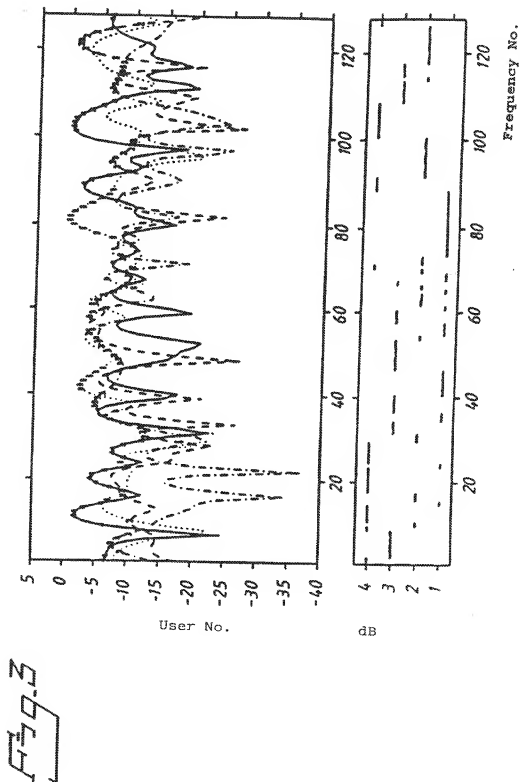
9. Arrangement according to any of the preceding claims, **characterized** in that allocated frequencies are given
35 amplitudes which are essentially at a maximum for all the four radio channels.

10. Arrangement according to any of the preceding
40 claims, **characterized** in that the users are allocated a

predetermined number of frequencies which is the same for all users, in that the element (6, 6', 6") detects/measures all the frequencies of the system continuously or at intervals which can be predetermined, and in that the element connects
5 and disconnects frequencies to the users in dependence on the variation in the frequency attenuations.

Fig. 1*Fig. 2*

2/2



INTERNATIONAL SEARCH REPORT

International application No.

PCT/SE 94/00841

A. CLASSIFICATION OF SUBJECT MATTER

IPC6: H04B 7/12, H04B 7/26

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC6: H04B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPODOC, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	DE, A1, 3621679 (EUGEN BEYER, ELEKTROTECHNISCHE FABRIK GMBH & CO), 14 January 1988 (14.01.88), column 1, line 3 - line 15; column 1, line 54 - column 2, line 1, abstract	1
X	--	2-10
P,A	FR, A1, 610988 (LABORATOIRES D'ELECTRONIQUE PHILIPS), 17 August 1994 (17.08.94), column 2, line 15 - line 50, abstract	1
P,Y	--	2-10

☒ Further documents are listed in the continuation of Box C.☒ See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to state the state of the principle or theory underlying the invention

"X" document of particular relevance: the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance: the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search

Date of mailing of the international search report

17 February 1995

17 -02- 1995

Name and mailing address of the ISA/
 Swedish Patent Office
 Box 5055, S-102 42 STOCKHOLM
 Facsimile No. +46 8 666 02 86

Authorized officer

Elisabet Åselius

Telephone No. +46 8 782 25 00

INTERNATIONAL SEARCH REPORT

International application No.

PCT/SE 94/00841

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US, A, 5203012 (STELIOS J. PATSIOKAS ET AL), 13 April 1993 (13.04.93), column 5, line 57 - column 7, line 9	1
Y	---	2-3,5-6,8-10
A	WO, A1, 9118458 (THE SECRETARY OF STATE FOR DEFENCE IN HER BRITANNIC MAJESTY'S GOVERNMENT OF THE UNITED KINGDOM OF GREAT BRITAIN AND NORTHERN IRELAND), 28 November 1991 (28.11.91), abstract	1-10
A	US, A, 5058133 (JAY P. DUNCANSON ET AL), 15 October 1991 (15.10.91), abstract	1-10

INTERNATIONAL SEARCH REPORT
Information on patent family members

31/12/94

International application No.

PCT/SE 94/00841

Patent document cited in search report		Publication date	Patent family member(s)		Publication date
DE-A1-	3621679	14/01/88	NONE		
FR-A1-	610988	17/08/94	NONE		
US-A-	5203012	13/04/93	AU-A-	3661593	03/09/93
			CN-A-	1075389	18/08/93
			EP-A, A-	0626121	30/11/94
			FI-A, D-	943312	12/07/94
			WO-A-	9316567	19/08/93
WO-A1-	9118458	28/11/91	AU-B-	637703	03/06/93
			AU-A-	7759991	10/12/91
			EP-A-	0527819	24/02/93
			GB-A, B-	2259228	03/03/93
US-A-	5058133	15/10/91	AU-A-	8224591	02/03/92
			WO-A-	9202992	20/02/92